SEED DISPERSAL AND SOIL SEED BANK OF *SERIPHIDIUM QUETTENSE* (ASTERACEAE) IN HIGHLAND BALOCHISTAN, PAKISTAN

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ABSTRACT

Seed dispersal and soil seed bank attributes of *Seriphidium quettense* were studied over two years in highland Balochistan. Seed dispersal started in early winter and continued till early spring. Primary dispersal agents were wind and water. Dispersal unit was capitulum, most often without outermost whirl of phyllaries. There was generally one achene per capitulum but occasionally two to three achenes may also be present. Mean dispersal distance was 23 to 40 cm from parent plant to ground surface. Majority of seeds (59–65%) fell under canopy of parent plants. Sampling of soil for seed bank was done before and after seed dispersal of *S. quettense*. Soil samples were collected from two depths (0–2 cm, 2–4 cm) and from two microhabitats (under adult individuals and open interspaces) by using soil cores. Seed bank status was determined by observing *S. quettense* seedling emergence in the pots. *Seriphidium quettense* exhibited persistent soil seed bank attribute. High seed densities were found under canopy of adult individuals and in upper soil layer. Persistent soil seed bank may help seeds to occupy safe sites as they develop over time.

KEY WORDS: *Seriphidium quettense*, seed bank, seed dispersal

RESUMEN

Se estudió la dispersión de las emillas y el banco de semillas del suelo de *Seriphidium quettense* durante dos años en las tierras altas de Balochistan. La dispersión de semillas comenzó a principios del invierno y continuó hasta principios de primavera. Los agentes dispersantes primarios son el viento y el agua. La unidad de dispersión es el capítulo, la mayoría de las veces sin los filarios externos. Normalmente hay un aquenio por capítulo pero ocasionalmente pueden estar presentes ods o tres. La distancia media de dispersión fue de 23 a 40 cm desde la planta madre hasta la superficie del suelo. La mayoría de las semillas (59–65%) cayó bajo el dosel de las plantas madres. El muestreo del suelo para el banco de semillas se realizó antes y después de la dispersión de las semillas de *S. quettense*. Se colectaron muestras de suelo a dos profundidades (0–2 cm, 2–4 cm) y de dos microhábitats (bajo individuos adultos y en los espacios abiertos entre ellos) mediante núcleos de suelo. El estatus del banco de semillas se determinó observando la la aparición de plántulas de *S. quettense* en los puntos de muestreo. *Seriphidium quettense* muestra una persistencia de su banco de semillas. Se encontraron altas densidades de semillas bajo el dosel de los individuos adultos y el la capa alta del suelo. La persistencia del banco de semillas del suelo puede ayudar a las semillas a ocupar lugares seguros y desarrollarse tiempo después.

INTRODUCTION

About 93% of the total area of Balochistan is classified as rangelands and 90–95% feed requirements of sheep are met by these rangelands (Quraishi et al. 1993). About 87% of people of Balochistan derive their livelihood directly or indirectly from livestock rearing (Heymell 1989). However, rangelands of Balochistan are degrading very rapidly by overgrazing and removal of vegetation for fuel wood. Re-establishment of native plant species is one of the options to restore the productivity of degraded rangelands.

In arid and semiarid rangelands, re-establishment of native plant species is vital to maintain function, structure, diversity, and stability of the landscape. Native species have evolved under the prevailing stresses of the region and have the ability to exploit the limited available resources. *Seriphidium* and *Artemisia* species are the dominant dwarf shrubs of Balochistan. The genus *Seriphidium* comprises of 125 species distributed

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in North America, temperate Asia and Europe (Ghafoor 2002). *Seriphidium quettense* (Podlech) Ling. (Syn. *Artemisia quettensis* Podlech) provides forage for small ruminants when other range species are in short supply particularly under drought conditions. Shrubs provide many benefits to humans and animals including fodder for livestock and wildlife, functioning of rangeland ecosystems, erosion control, industrial products and medicines (McKell 1989).

Regeneration of most range species depends on seed production, seed dispersal, seed predation, soil seed bank, suitable environmental conditions, and presence of suitable microsites (Chambers & MacMahon 1994; Watkinson 1978). Seed dispersal can determine size, structure and composition of plant population and diversity of plant community (Askew et al. 1997; Peart 1979). Soil seed bank enables plant populations to maintain their genetic variability, withstand adverse periods, and persist through time (Baskin & Baskin 1978; Thompson & Grime 1979). Soil seed bank have both horizontal and vertical dimensions as a result of phase I and phase II dispersal (Chambers & MacMahon 1994; Guo et al. 1999; Simpson et al. 1989). Such distribution of seeds has a great impact on population growth and its structure (Chambers & MacMahon 1994). Seeds are present in high densities under plant canopies in arid habitats representing horizontal pattern of seed banks in soil (Guo et al. 1999). The present study was conducted to determine the pattern of seed dispersal of *Seriphidium quettense* and evaluate temporal and spatial status of its soil seed bank.

MATERIALS AND METHODS

Study site

The experiment was conducted in Chiltan National Park Hazarganji, Balochistan, Pakistan in an extended area of the park that was protected from livestock grazing since 1998. Climate of the area is Mediterranean type. Area receives rainfall mostly during the winter months. Occasionally rainfall occurs during the summer as well. Mean annual rainfall of over 19 years is 200 mm. Soil of the area is sandy-to-sandy loam. Dominant species of the site are *Seriphidium quettense, Cymbopogon jawarancusa, Chrysopogon aucheri* and annual grasses (Marwat et al. 1992).

Seed dispersal

Experiments were conducted for two-year to determine the pattern of seed dispersal in *S. quettense*. In Asteraceae (Compositae) the dispersing unit is a fruit, an achene or cypsela. However, the term seed is used in this study for the fruit dispersal. Fifty meters long transects were established during December 2002 and December 2003. Ten points were marked along the transect during each year and the nearest plant was selected on each point. Inflorescences of other plants within 3 meters radius were clipped to prevent confounding of the seeds. Fluorescent powder was applied to the selected plants prior to seed dispersal. Seed dispersal was observed at five days interval until the end of dispersal period. Distance of seed dispersal was measured from the edge of the base of the marked plants. Seeds were collected after measuring the distance. Percentage of dispersed seeds was determined in two microhabitats under parent plant canopy and open interspaces. The data were subjected to linear regression analysis between number of seeds dispersed and dispersal distance.

Soil seed bank

Temporal and spatial status of *S. quettense* seed bank in the soil was examined for two years from two depths (0–2 cm, 2–4 cm) and from two microhabitats (under canopy of adult individuals, and open interspaces). Samples were collected before and after fresh seed dispersal to assess temporal aspect of soil seed bank. Fifty meter long transects were established at each sampling date. Ten points were marked on transect lines. Five samples were collected under adult individuals and from open interspaces at 0–2 cm and 2–4 cm depths at each marked point by using 10 cm diameter soil core. First sampling before the seed dispersal period was done in mid November during 2002 and 2003. Second sampling was done in late February during 2003 and 2004. As seeds of *S. quettense* are 0.8 mm in size (Ghafoor 2002), 0.5 mm mesh sieve was used to remove gravel and unnecessary soil, to ensure maximum retention of seeds in the sample for their germination. The sub samples were pooled and filled in pots for observing seedling emergence. Pots were placed in open air

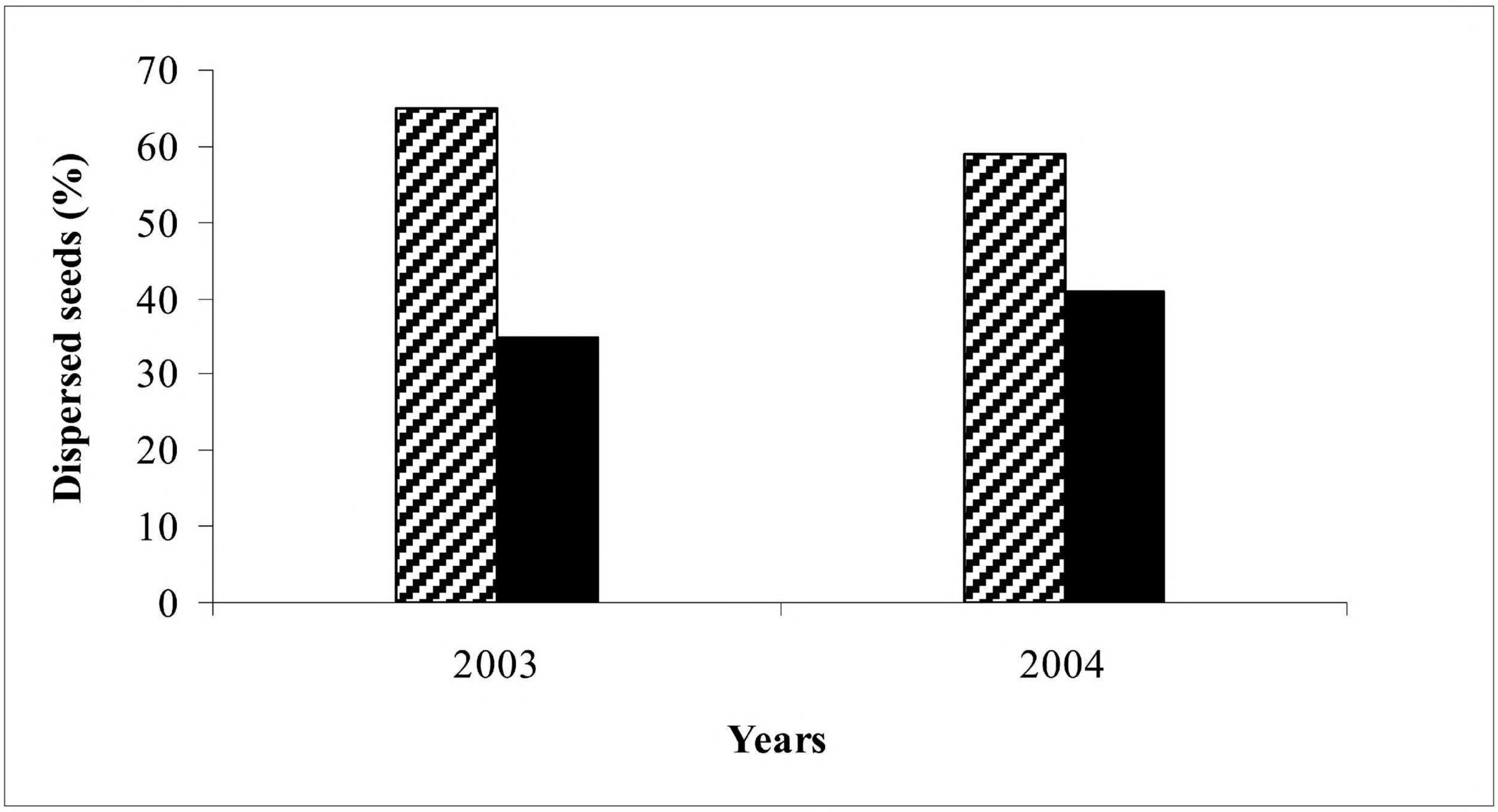

Fig. 1. Percentage of dispersed seeds (capitula) under parent plant canopies (▨) and in open interspaces (■) during 2003 and 2004

and watered regularly. The emerging seedlings were identified, counted and removed. Seedling emergence was observed for three months. First year samplings were germinated in mid March and the second year samplings in the last week of February.

RESULTS

Seed dispersal

Seed dispersal of *S. quettense* started from mid to late December and continued till late February. Primary dispersal agents were wind and water. Dispersal unit was a capitulum, most often without outermost whorl of phyllaries. There was generally one achene per capitulum but occasionally two to three achenes may also be present. Maximum dispersal distance was 130 cm and 210 cm for first and second year respectively. The mean dispersal distance from parent plants to ground surface was 23 to 40 cm for first and second year respectively. Seeds distributed in all directions around the plants. However, majority of seeds were found in northeast side according to wind direction. Majority of the seeds (59–65%) fell under canopy of parent plants (Fig. 1). There was a negative correlation between dispersal distance and number of the seeds (Fig. 2a, b). Number of the seeds decreased as the distance increased and created a negative exponential curve (Fig. 2a, b).

Soil seed bank

Seed densities of *S. quettense* varied with microhabitats and soil depths for each sampling date (Fig. 3a,b,c,d). High seed densities were found in the upper 0–2 cm soil layer than the lower 2–4 cm and under the adult individuals than in the open interspaces. In the first year sampling, microhabitats and depths were significant ($p<0.05$) for the second sampling while non-significant for the first sampling (Fig. 3a,b). In second year samplings, differences in numbers of seedlings between microhabitats were significant ($p<0.05$) for both samplings as a higher number of seeds were observed under canopy of adult individuals. Differences between soil depths were non-significant for both samplings (Fig. 3c,d). A high number of seeds were found in upper soil layer.

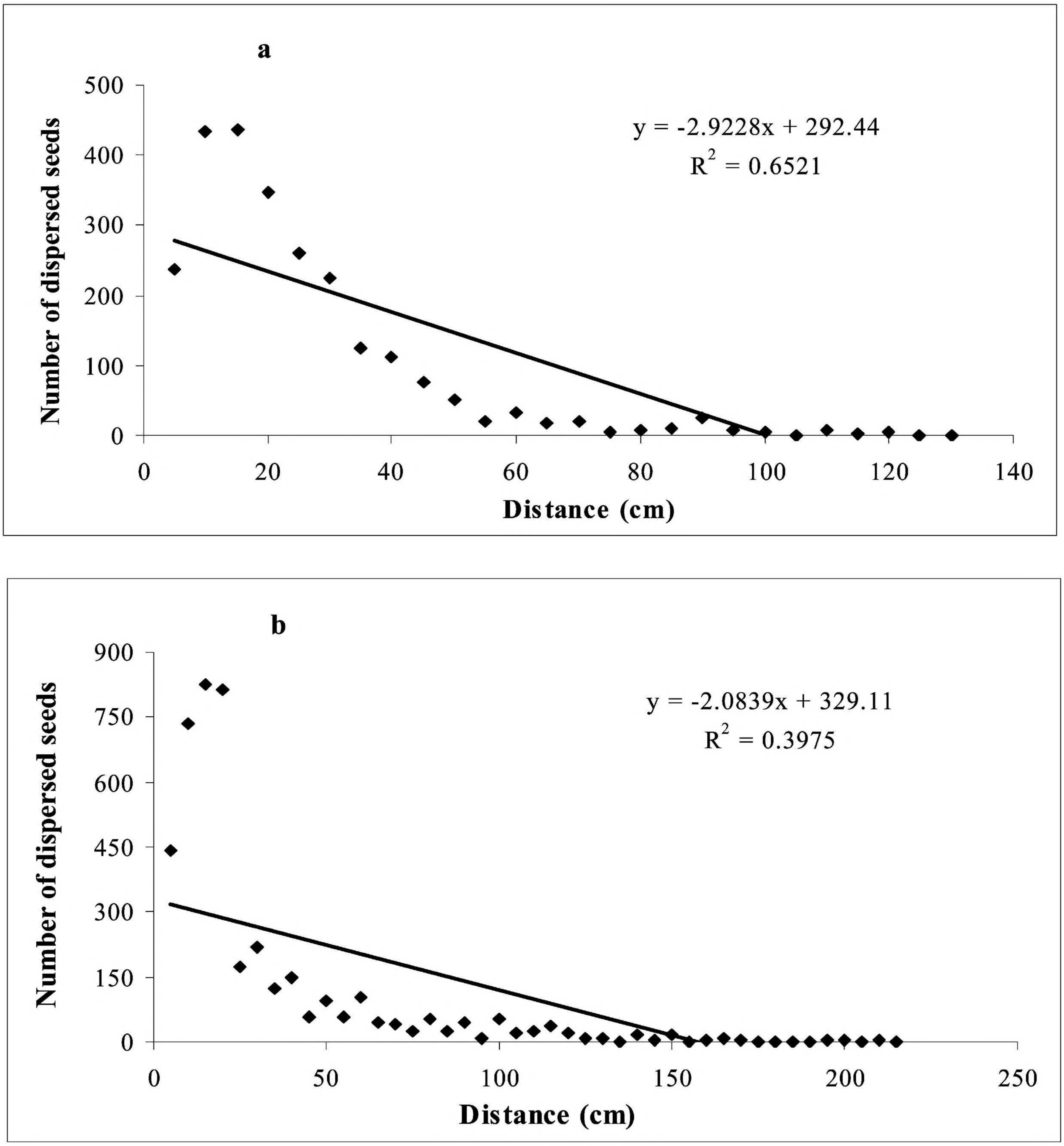

Fig. 2. Pattern of seed dispersal in *Seriphidium quettense* from parent plants to the ground surface during year 2003 (a) and 2004 (b). Lines are based on regression equations, where Y is number of dispersed seeds (capitula) and X is distance from parent plants.

DISCUSSION

Seriphidium quettense had a prolonged period of seed dispersal which started from early winter and lasted till early spring. Prolonged dispersal has also been reported for fringed sagebrush (Bai & Romo 1997). Although predation on *S. quettense* seeds is unknown, but prolonged dispersal is believed to be helpful in avoiding predation (Willson 1993). Longer periods of seed dispersal in *S. quettense* seems to be a tactic for contemporary seed germination as well as for the chances of seed burial in the soil (Davlaeminck et al. 2005; Mahmood et al. 2005; Olano et al. 2002). Though seeds of *S. quettense* are very light, dispersal was limited with a majority of seeds falling under the canopy of adult plants. Restricted dispersal of seeds around the

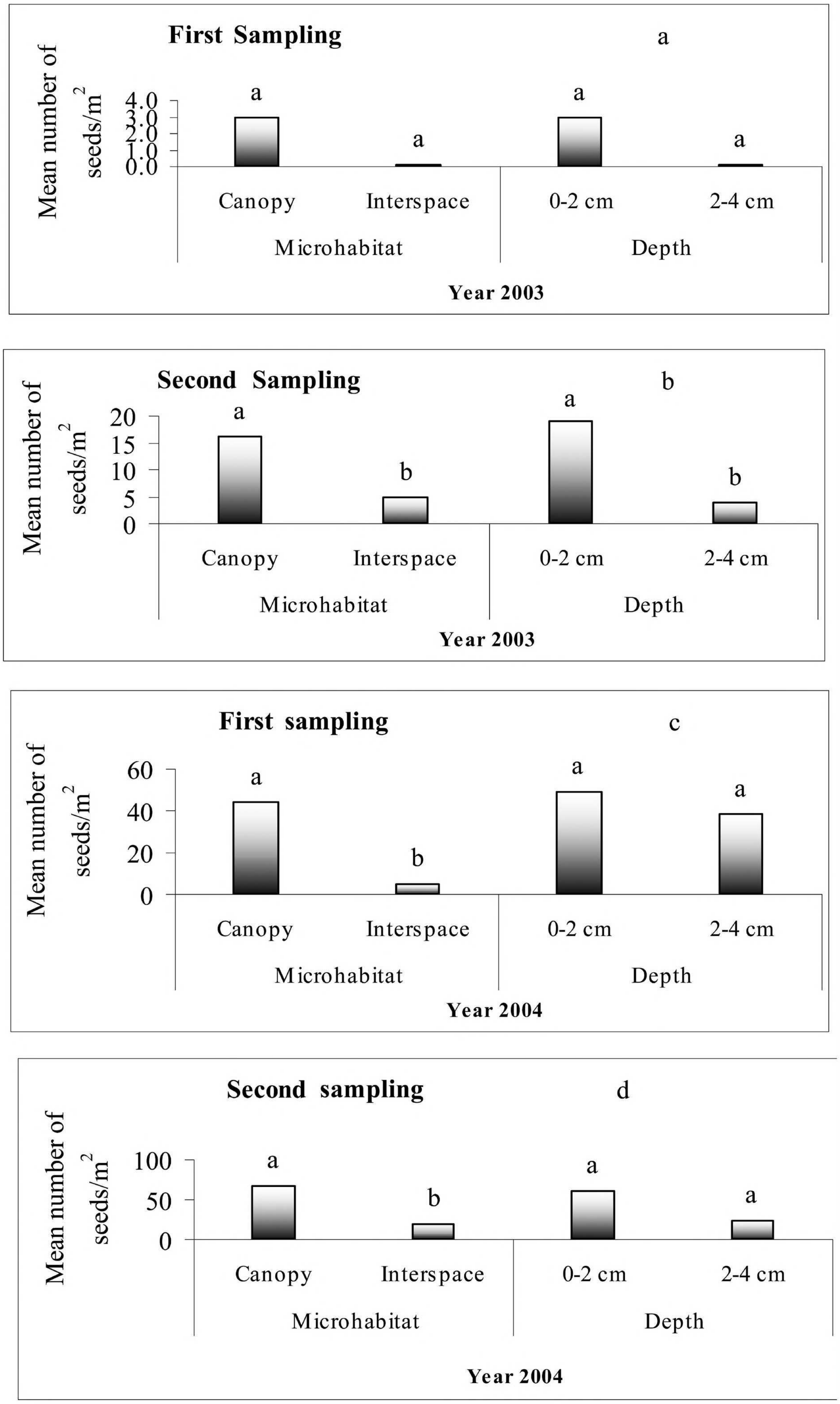

Fig. 3. Temporal and spatial pattern of soil seed bank. Means followed by the same letters are not significantly different at P=0.05.

parent plants signifies safe sites for seed germination (Davlaeminck et al. 2005; Mahmood et al. 2005). Characteristics like seed weight, size, shape, height of parent plants, and the nature of surrounding vegetation are important determinants when wind and gravity are the primary agents for seed dispersal (Willson 1993). The limited seed dispersal has also been reported for other species of *Artemisia* (Bai & Romo 1997; Bauer et al. 2002; Friedman & Orshan 1975) and has been attributed to low release height of the parent plants (Bauer et al. 2002). Phase II dispersal of seeds in horizontal and vertical direction may have greater influence on patterning of plants in ecosystems than their initial dispersal (Chambers & MacMahon 1994; Russel & Schupp 1998). There are greater chances of rain in the area during January and February that may help farther movement of the seeds and can greatly affect seed germination and seedling establishment.

Densities of emerged seedlings of *S. quettense* in pots ranged from 3 to 68 per m^2. Seed densities of fringed sagebrush in mixed prairie in Alberta have been reported as 75 to 183 per m^2 (Johnston et al. 1969). In second year, seedling densities were higher due to variation in sampling site and early placement of samples in the pots than the first year. Increasing temperature may hinder germination of these species (Bai & Romo 1994; Booth & Bai 1999). Roberts (1981) reported that use of seedling emergence techniques to quantify soil seed bank status may under estimate the soil seed bank density if germination requirements are not met. Soil seed bank of *S. quettense* showed variable spatial and temporal patterns across different samplings. Both increasing and decreasing trends have been reported for total number of seeds of *S. tridentatum* with distance from canopy center (Guo 1998). Canopies of *S. quettense* retained more seeds than open interspaces in all samplings. It may be attributed to the limited dispersal of the seeds and comparatively high quantity of litter under canopies as compared to bare interspaces (Russell & Schupp 1998).

Higher seed densities were found in upper soil layer (Guo et al. 1999). Small seeds are more prone to move downward in loose textured soils in arid environment as compared to larger ones (Chambers & MacMahon 1994). The period of seed dispersal of *S. quettense* immediately follows spring season. That can increase germination due to greater chances of rainfall during late winter or early spring.

Seriphidium quettense has a persistent soil seed bank and seedlings emerged from first samplings before the seed dispersal period. Our findings are in conformity with previous studies that small seeds and seeds of disturbed habitats generally form persistent soil seed bank (Bai et al. 1995; Bai & Romo 1997; Mahmood et al. 2005). Prolonged seed dispersal and persistent soil seed bank attributes of *S. quettense* may help their seeds to occupy safe sites as they develop over time.

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